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Annular rotary hearth furnace for heat-treating workpieces

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Abstract of GB2162294

In a furnace for heat-treating workpieces with a rotary annular hearth 4, the hearth 4 is driven stepwise with each step (h) being an integral fraction of the hearth circumference, and the annular space of the furnace is subdivided by a plurality of simultaneously movable partitions 9-12 spaced from one another by integral multiples of a step (h), whereby the furnace is provided with separate treatment zones 16-19 with different temperatures and atmospheres. The annular space is conveniently subdivided into a loading and unloading zone 16, a heating-up zone 17, a carburisation zone 18 and a diffusion annealing zone 19. The hearth 4 may be driven by a hydraulic cylinder 13 connected by a ratchet device to a ring gear on the hearth, and may be subdivided into segments provided at their joints with sealing means 23 for the partitions 9-12. Workpiece receiving shelves may be provided above the hearth, with slots for the passage of the partitions.

SPECIFICATION

Rotary furnace of annular construction for heat-treating workpieces

The invention relates to a rotary furnace of annular construction for heat-treating workpieces, the furnace having a rotary hearth, rotary drive means and a closable loading and unloading aperture, as is known from industrial practice. Volume No. 8 "Die Haerterei" (The Hardening Shop), page 40, from the
"Werkstattbuecher" (Shop Manuals) series may be mentioned as a literature source in this context.

The known furnaces of this type have an at least approximately plane annular hearth plate, which is mounted rotatably and driven slowly and continuously in rotation. The rotary hearth runs in a U-shaped masonry furnace surround enclosing an annular channel. A closable loading and unloading aperture, through which the stock to be treated can be introduced into the furnace and removed from it, is provided at a given point on the circumference. Forms of construction are also known in which separate apertures and/or flaps for loading the furnace and/or for removing the treated stock are provided juxtaposed at close intervals. The separate arrangement of loading and unloading flaps presents the possibility of placing a stationary partition radially into the annular space, so as to be able to maintain more easily a jump of temperature between the start and the end of the revolving stage.

The stationary partition has the disadvantage that the treated stock has to be completely removed

after one revolution. The rotary hearth is however operated with a continuous revolution of its hearth plate in every case. In rotary furnaces with a stationary partition in the loading and unloading zone, the treatment time corresponds to one revolution of the rotary hearth, whereas a rotary furnace with no partition admits of any length of treatment time, and also different treatment times for the stock to be hardened. If possible, the treatment should not take place with the rotary hearth stationary, in order to ensure the same conditions of heat treatment for all the workpieces introduced by a revolution of the rotary hearth.The known rotary hearths have the disadvantage that it is impossible with them to maintain a different furnace atmosphere, in temperature or composition, round the circumference of the annular treatment space. Even a stationary partition in the region of the loading and unloading zone makes very little difference to this; a temperature jump of20-30"C at most can be maintained by this means. The furnace atmosphere is also continually disturbed by the loading and unloading operations, so that the small temperature jump, which is intended per se, is more or less "blunted" by this factor.

In addition to the above, the so-called "push-through" furnaces are also known, in which the treated stock is stacked on refractory pallets, which are then pushed positively and consecutively sliding through the straight treatment space as blocked columns by a push-through apparatus whilst at each stroke a new pallet is added in front and a treated pallet removed at the end. The feeding and removal of pallets occurs transversely to the push-through direction; locks are provided at these feeding stations and removal stations due to this complicated and: relatively protracted changing and removal of pallets into and out of the column.By adopting this furnace principle, it is also possible to produce treatment furnaces with greatly different furnace atmospheres, whilst for each treatment zone with a different furnace atmosphere it is necessary to provide a separate push-through line, which adjoins the preceding line at right angles with interposition of an appropriate lock. For this reason, such push-through furnaces with different furnace atmospheres are extremely onerous in construction, expensive and fault-prone. The current requirement of expensive refractory pallets, which are subject to continuous wear during service, is also a disadvantage. Another disadvantage of the use of pallets is that they also have to be heated-up whereby increased energy is consumed.Another disadvantage of the pushthrough furnaces with a plurality of mutually separate treatment zones lines in the fact that it is impossible to achieve short cycle times with them. The many locks and push-through paths dictate a chronological sequence of opening, closing and sliding operations, which add up to a relatively long overall time. The overall time represents, in a sense, the lower limit of the shortest cycle time which can be achieved. Shorter cycle times are however frequently desirable for shallow hardening depths, but they cannot be realised in such a furnace, or only be accepting disadvantages, such as incomplete utilisation of the furnace capacity, for example.

The aim of the invention is to develop a rotary furnace in such a way that, for a relatively small structural outlay, hardening operations with greatly different furnace atmospheres can be performed, whilst extremely short cycle time or treatment times should also be practicable.

According to the present invention there is provided a rotary furnace of annular construction for heat-treating workpieces, the furnace including an annular rotary hearth, a rotary drive means for driving the rotary hearth and a closable loading and unloading aperture, wherein the rotary drive means is constructed to operate stepwise with a predetermined conveying stroke corresponding to an integral fraction of the rotary hearth circumference, the annular space of the rotary furnace being subdivisible by a plurality of movable partitions into a plurality of separate treatment zones, whilst the mutual circumferential spacing of the partitions corresponds to an integral multiple of the conveying stroke.

By virtue of the subdivision of the annular space of the furnace into a plurality of treatment zones by movable partitions, greatly different furnace atmospheres can be maintained. At the same time, the conveying stroke of the cyclically driven rotary hearth is co-ordinated with the spacings of the partitions. Only a single drive means, simple and light in construction, is provided for the rotary hearth for the passage of the parts through the annular treatment hearth, so that the onerous and fault-prone "pushers-through" and locks can be eliminated. Separate pallets are no

longer required because the stock for treatment can be placed directly upon the hearth or upon stacking mandrels et cetera which remain in the furnace. This not only eliminates costs for expensive pallets or stacking grids, but also the energy costs for their continual reheating.Moreover, the parts immediately have a definite place within the furnace, which they maintain during the entire treatment, so that automatic loading and unloading by means of industrial robots is immediately possible. Since the various partitions which separate the various treatment zones from each other are all activated simultaneously, the overall times necessary for the stepped advance of the furnace by one segment are relatively short, so that extremely short cycle times, and therefore treatment times, can be achieved with such a furnace. It is therefore possible to practise even shallow hardening depths with full utilisation of the furnace capacity.

Preferably, a partition is arranged on each circumferential side immediately adjacent the loading and unloading aperture at a mutual circumferential spacing of a conveying stroke to produce a locklike loading and unloading zone. The annular space may be subdivided into a heating-up zone, a carburisation zone and a diffusion annealing zone. Preferably, the loading and unloading zone is heatable.

In a preferred embodiment, the rotary hearth is subdivided into segments each having a circumferential extent corresponding to the conveying stroke (h), in which case the segments may be each provided at their mutual joint positions with sealing means for the fluid-tight reception or support of the bottom edge of a partition. The sealing means may be constructed as radially oriented bars, the partitions being adapted to rest by their bottom edges on the bars.

The rotary hearth may have a plurality of charging planes and the segments associated with the upper charging planes have slits at their respective joint positions for the passage of the partitions.

The invention will now be described by way of example with reference to the drawings, wherein:
Figure 1 shows a plan of a rotary furnace with a plurality of mutually partitioned treatment zones,
Figure 2 shows a cross-section through the annular rotary furnace according to Fig. 1 along the line of sectionll-ll and
Figure 3 shows a plan view of an automatised hardening installation with automatic loading and unloading of the rotary furnace, followed by chilling in hardening presses, workpiece cleaning and stress removal annealing.

The rotary furnace 24 illustrated in the drawings consists substantially of an outer ring 1, an inner ring 2 and an annular cover 3, each made of refractory masonry, which are held together by a supporting structure 6.

Arranged in the interior of the furnace of Ushaped cross-section formed in this manner is the annular rotary hearth 4, which is supported on stationary supporting rollers 5 and sealed gastightly relative to the stationary masonry furnace surrounded by means of annular sand cups. A ratchet ring gear 15, which is fitted to the underside of the hearth, is engaged by at least one expansible hydraulic ram and cylinder. device. By the rotary drive means produced in this manner, the rotary hearth 5 can be advanced stepwise in rotation by a definite conveying stroke (h) in the direction of rotation1 4. The conveying stroke (h) corresponds to an integral fraction of the total rotary hearth circumference. The rotary hearth 4 is subdivided into segments 8 corresponding to this conveying stroke.

A furnace flap 7 to close a loading and unloading aperture is provided at a point on the circumference of the outer ring 1. The furnace space can be brought to temperature

by flame-heated or electrically heated jet pipes 20. The furnace atmosphere can be circulated by blowers 21. To permit treatment zones with greatly different furnace atmosphere as regards temperature and/or composition to be maintained in the annular space of the fur nace, a plurality of movable partitions 9 to1 2 are provided at the circumference of the annu lar space, the mutual circumference spacing of which corresponds to an integral multiple of a conveying stroke (h). In the exemplary embodiment illustrated the partitions are verti cally raisable, and the corresponding shaft is closed towards the top by a gas-tight, ther mally insulating, cowl-like partition cover 22.

The drive to the partitions may be effected via chains by means of a reciprocatable cylinder.

A partition 9 or1 2 respectively is fitted on each of the two sides immediately behind the loading and unloading aperture, in order to produce a locklike loading and unloading zone; in this case, however, the circumferen tial interval of the two partitions 9 and1 2 is only a single conveying stroke. A heating-up zone 17, which comprises three segments in the embodiment illustrated, is arranged behind the first partition 9 in the direction of rotation. The workpieces should be warmed in this zone initially nearly to the range of the carburisation temperatures with economy of energy and of treatment gas. A furnace atmosphere of inert behaviour prevails in this heating-up zone. The end of the heating-up zone is determined by a further partition1 0.

This is followed by the carburisation zone 18, which extends over more than half the circumference of the furnace. A carburising furnace atmosphere prevails in the latter; the furnace temperature here are relatively high within the range for carburisation temperatures, in order to permit a rapid absorption of carbon. A further partition 11 is fitted at the end of the carburisation zone1 8. Due to the rapid carburisation, a steep concentration gradient of carbon is present in the outer peripheral layer of the workpieces, which is undesirable. In order to equalise this carbon concentration in the peripheral region, there also follows a diffusion annealing zone 19, which extends to the last partition1 2 in front of the loading and unloading zone.Although lower temperatures prevail in this diffusion annealing zone, they still lie within the effective carburisation temperature range; moreover, the carbon potential in the furnace atmosphere is likewise somewhat lowered (approximately 0.8% C).

By virtue of this zonal subdivision of the treatment, it is possible on the one hand for much carbon to be introduced into the workpiece for relatively short carburisation times; on the other hand, an approximately constant carbon concentration can be obtained in the outermost periphery of the carburisation layer.

This treatment is economical of energy and also gentle to the material structure, that is to say, it prevents coarse grain formation.

To avoid impairing by the loading and unloading operations the furnace atmosphere present in the actual treatment zone, either in its temperature or in its composition, a locklike zone1 6 is created-as stated-in the loading and unloading region, which is closable from the exterior by a furnace flap 7. This zone is conveniently also heatable, which has the advantage that the breaks in temprature during the cyclic advance of the rotary hearth are less intense in the adjacent treatment zones1 7 and1 9. The heating of the loading and unloading zone is also convenient

particularly if the workpieces leaving the diffusion zone are required to be removed individually for chilling in a hardening press; they can then be maintained at annealing temperature in the loading and unloading zone.

As already mentioned, the rotary hearth is provided with a stepwise operating drive means which advances the rotary hearth by a definite conveying stroke (h) each time, whilst this measurement is an integral fraction of a complete circumference of the circle. For example, in the rotary furnace illustrated in
Fig. 1, a conveying stroke h is 1/24 of the circumference, which corresponds to an angle of15 . Corresponding to this conveying stroke h, the rotary hearth 4 is subdivided into corresponding segments 8, which are provided at their adjoining edges with means for the fluidtight reception or support of the bottom edge of the partitions 9 to 12. In fact, the sealing means are conveniently constructed in the form of radially oriented bars 23, upon the top side of which the partitions rest by their bottom edge, forming a seal.The bars may also be constructed as a U-shaped profile, in order to achieve even better sealing. In order to enlarge the capacity of the rotary furnace for workpieces, the rotary hearth may exhibit a plurality of charging planes after the manner of a shelf. The upper charging plane or planes are respectively provided with a slit between the individual segments for the passage of the partitions. The partitions may exhibit angular sealing strips at the relevant point, which engage in or past a corresponding recess or over a corresponding countersealing strip on the segment. The partitions themselves are conveniently formed as an abrasion-resistant ceramic plate made of highly heat-resistant material.

The automatically operating hardening installation illustrated in Fig. 3 has an an essential constituent a rotary furnace 24 constructred according to Figs. 1 and 2, with heating-up zone, carburisation zone and a diffusion annealing zone and also a separate loading and unloading zone. The loading and unloading is effected by a loading and unloading robot 25. The workpieces to be heattreated are dumped into a vibrating bin 26, from where they are first of all brought into an even orderly position and moved on a conveyor chute 27 to a withdrawal station 28 for the robot.There the robot can withdraw the workpieces in a correct position and insert them precisely into the loading zone1 6. During insertion, it is also possible for a plurality of workpieces to be inserted simultaneously mutually superposed or between coresponding receiving mandrels, so that the charging proceeds relatively rapidly. In the case of the hardening installation illustrated in Fig. 3 the withdrawal of the workpieces is required to occur individually, because the workpieces are required to be chilled individually in the hardening presses 29. As already indicated, by virtue of the heating of the loading and unloading zone1 6 the workpieces can be maintained at annealing temperature in the latter, so that individual withdrawal and individual chilling of the workpieces in hardening presses is possible.Obviously, the furnace flap 7 must be closed again after each withdrawal opertion. It would however be conceiv able for the robot to withdraw two workpieces simultaneously and to deposit these two workpieces consecutively upon the two hardening presses erected parallel. The workpieces are held in correct shape under high pressure in the hardening presses, so that they cannot become distorted, and chilled. The hardened workpieces are then ejected onto rollerways 30, from where they pass onto a conveyor belt 31. This conveyor belt carries the workpiece first of all through a washing machine 32 and then through a stress removal furnace 33, in which the inherent stresses are removed from the workpieces by moderate warming. The workpieces finally pass through a chute 34 into a further vibrating bin 35, from where they exit in orderly formation; they can then be palletised easily, mechanically or manually, for the further treatment of the workpieces.

CLAIMS

1. A rotary furnace of annular construction for heat-treating workpieces, the furnace including an annular rotary hearth, a rotary drive means for driving the rotary hearth and a closable loading and unloading aperture, wherein the rotary drive means is constructed to operate stepwise with a predetermined conveying stroke corresponding to an integral fraction of the rotary hearth circumference, the annular space of the rotary furnace being subdivisible by a plurality of movable partitions into a plurality of separate treatment zones, whilst the mutual circumferential

spacing of the partitions corresponds to an integral multiple of the conveying stroke.

2. A rotary furnace according to claim 1, wherein a partition is arranged on each circumferential side immediately adjacent the loading and unloading aperture at a mutual circumferential spacing of a conveying stroke to produce a locklike loading and unloading zone.

3. A rotary furnace according to claim 1 or 2, wherein the annular space is subdivided into a heating-up zone, a carburisation zone and a diffusion annealing zone.

4. A rotary furnace according to claim 2 or 3, wherein the loading and unloading zone is heatable.

5. A rotary furnace according to any one of claims 1 to 4, wherein the rotary hearth is subdivided into segments each having a circumferential extent corresponding to the conveying stroke.

6. A rotary furnace according to claim 5, wherein the segments are each provided at their mutual joint positions with sealing means for the fluid-tight reception or support of the bottom edge of a partition.

7. A rotary furnace according to claim 6, wherein the sealing means on the segments are constructed in the form of radially oriented bars the partitions being adapted to rest by their bottom edge on said bars.

8. A rotary furnace according to any one of claims 1 to 7, wherein the rotary hearth has a plurality of charging planes and that the segments associated with the upper charging planes have slits at their respective joint positions for the passage of the partitions.

9. A rotary furnace according to any one of claims 1 to 8, wherein the rotary drive means comprises at least one expansible hydraulic cylinder engaging the rotary hearth tangentially, whilst the point of engagement between the cylinder and the hearth comprises a ratchet wheel-type connection, the ratchet being overriden after each conveying stroke of the cylinder.

1 0. A rotary furnace substantially as described herein with reference to and as illustrated in the accompanying drawings.